The April-May 2015 Nepal Earthquake Sequence

The April 25, 2015 M 7.8 Gorkha Earthquake and its Aftershocks,
including the May 12, 2015 M 7.3 Event

Earthquake Educational Slides

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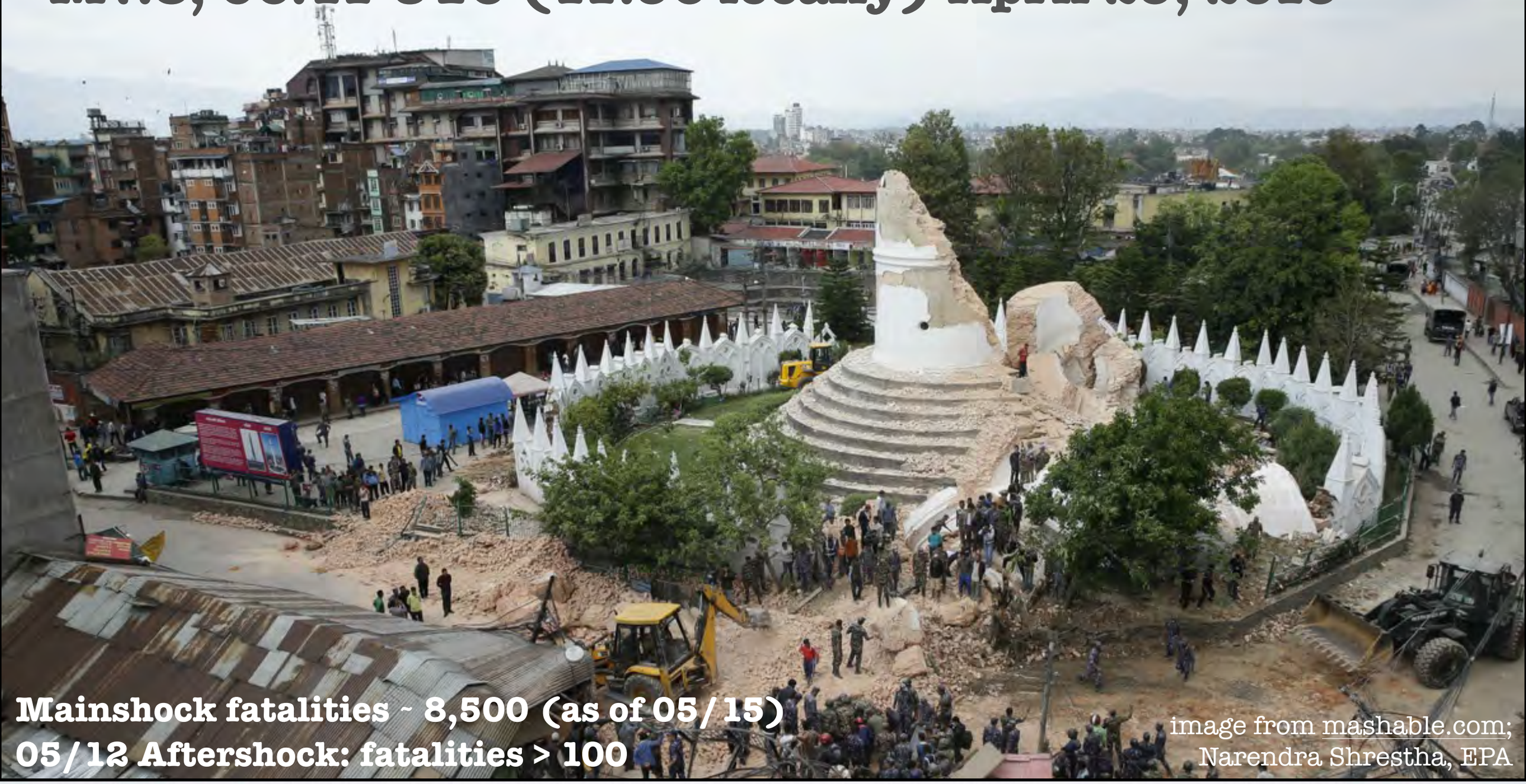
Mike Hearne, Paul Earle
USGS Geological Hazards Science Center

M7.8, 06:11 UTC (11:56 locally) April 25, 2015



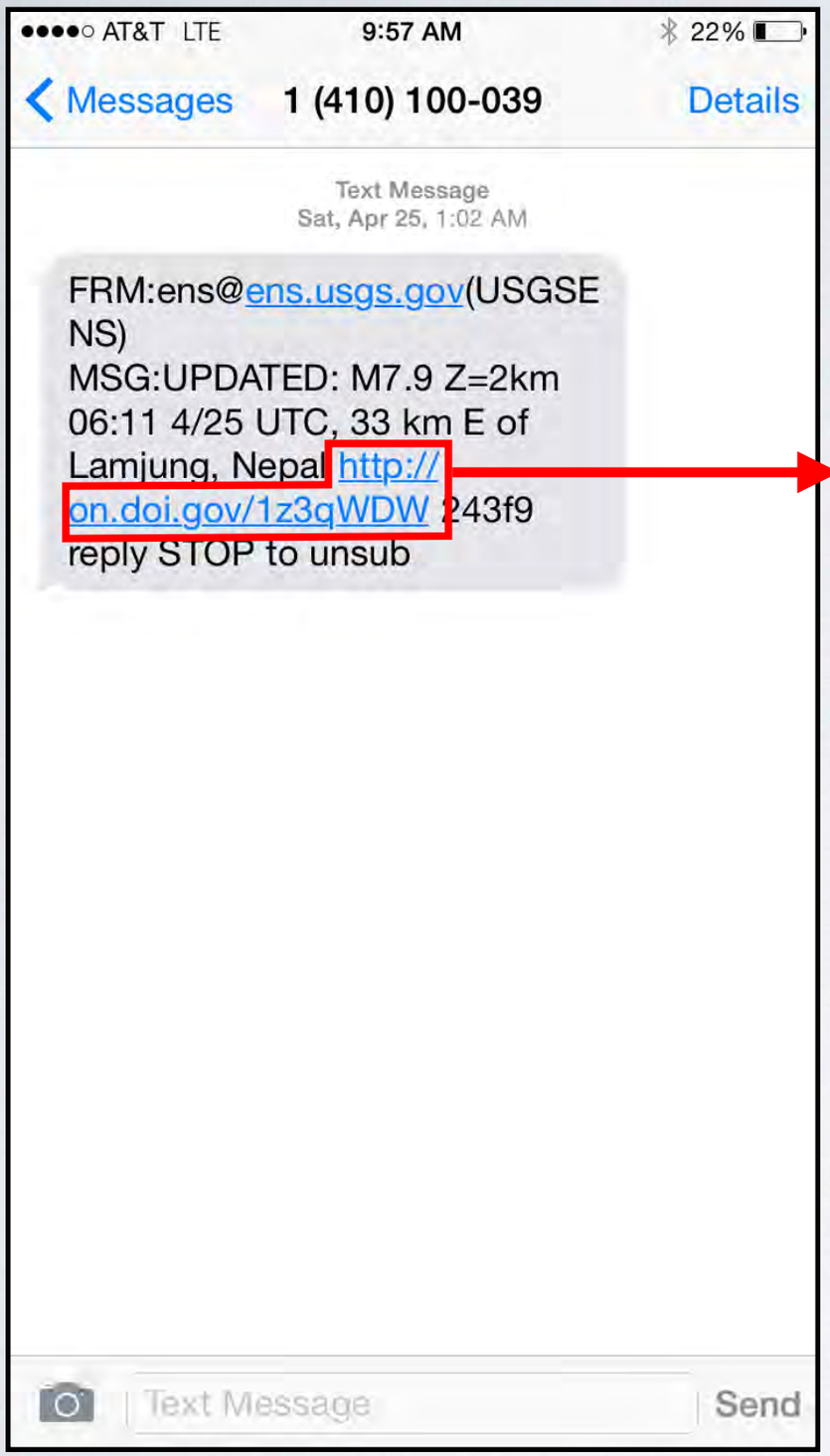
Mainshock fatalities ~ 8,500 (as of 05/15)
05/12 Aftershock: fatalities > 100

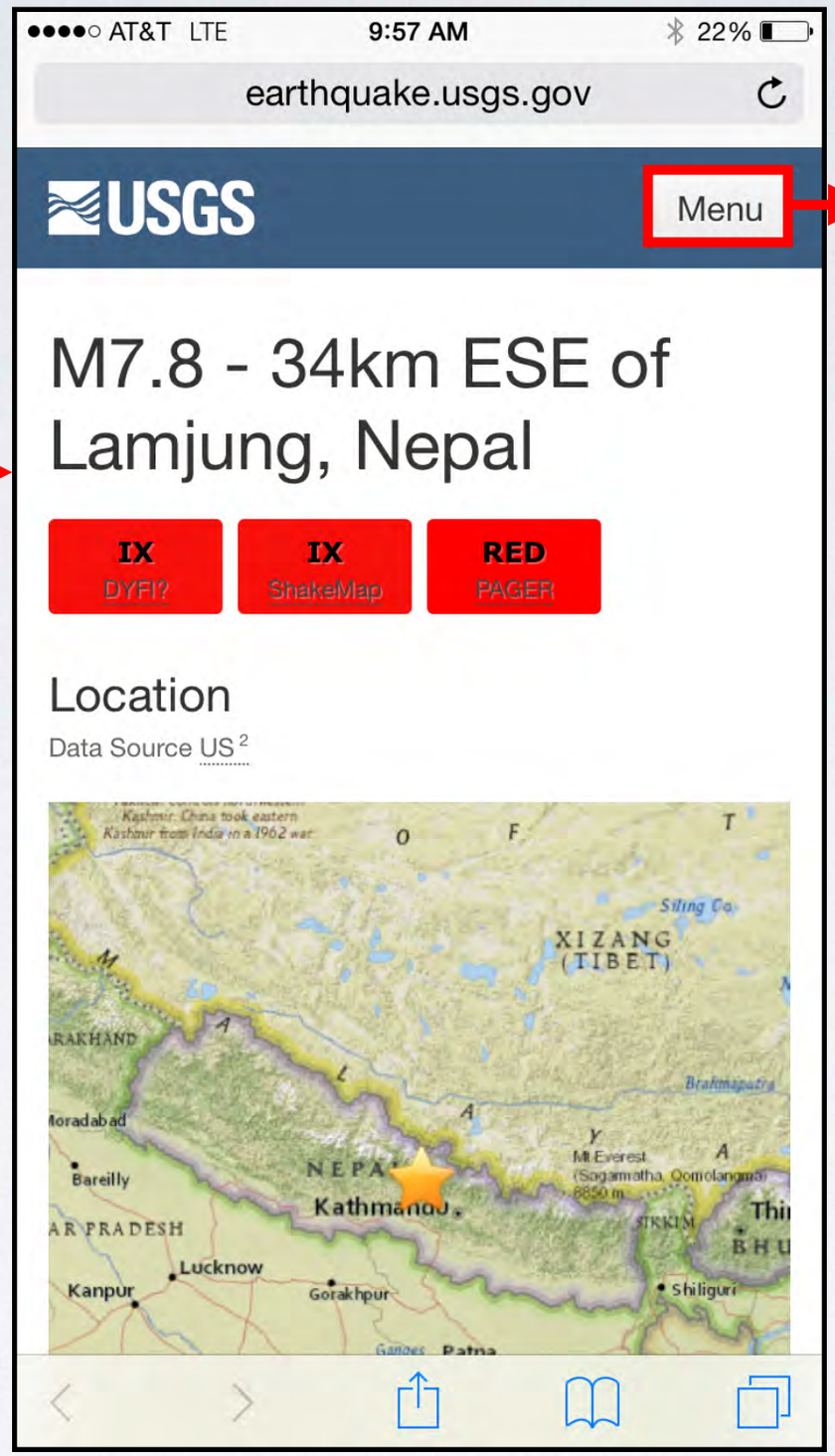
image from mashable.com;
Narendra Shrestha, EPA

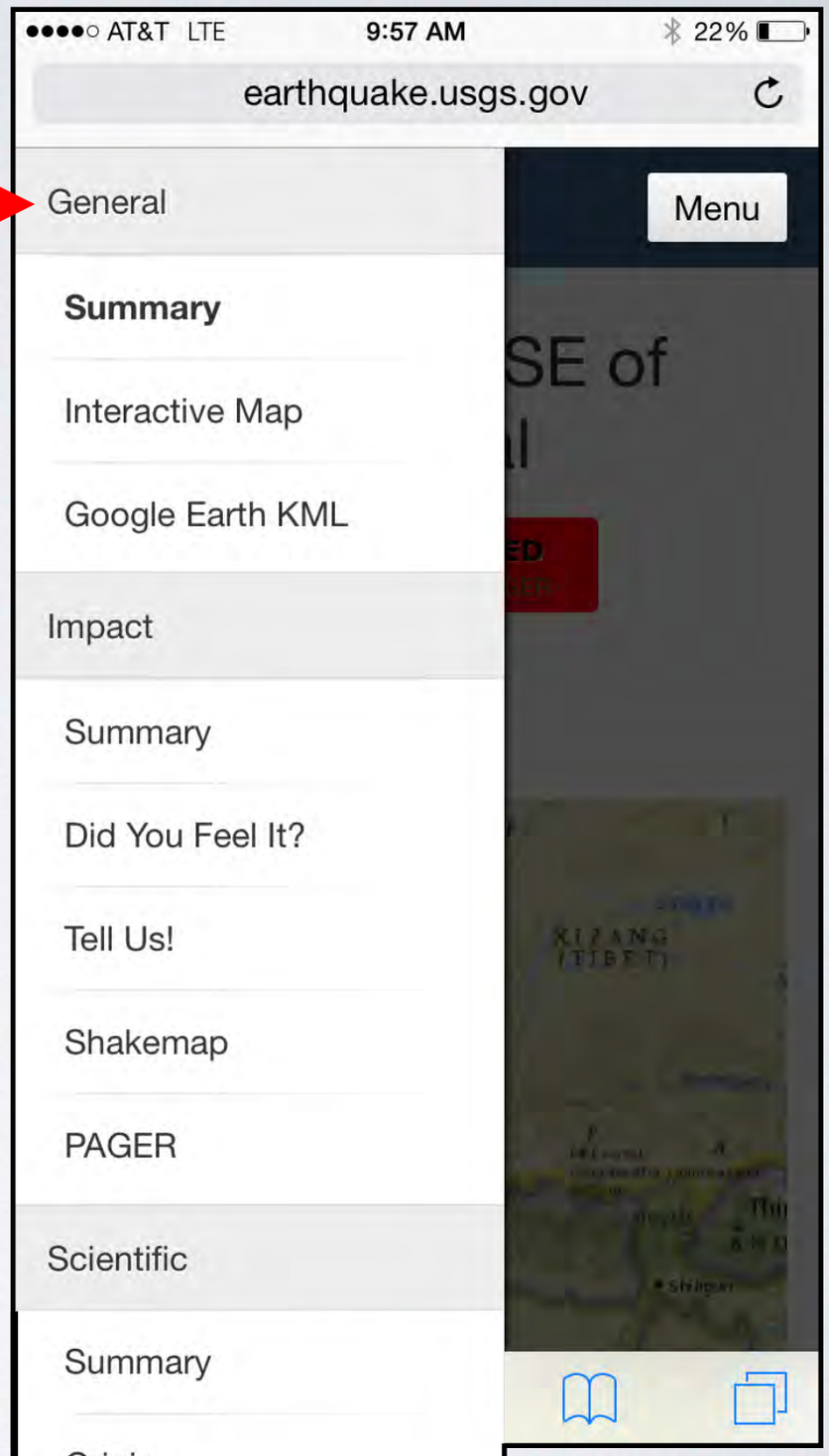
USGS Event Page: http://earthquake.usgs.gov/earthquakes/eventpage/us20002926#general_summary

USGS Earthquake Summary Poster: http://earthquake.usgs.gov/earthquakes/eqarchives/poster/2015/20150425.php

Earthquake Notification



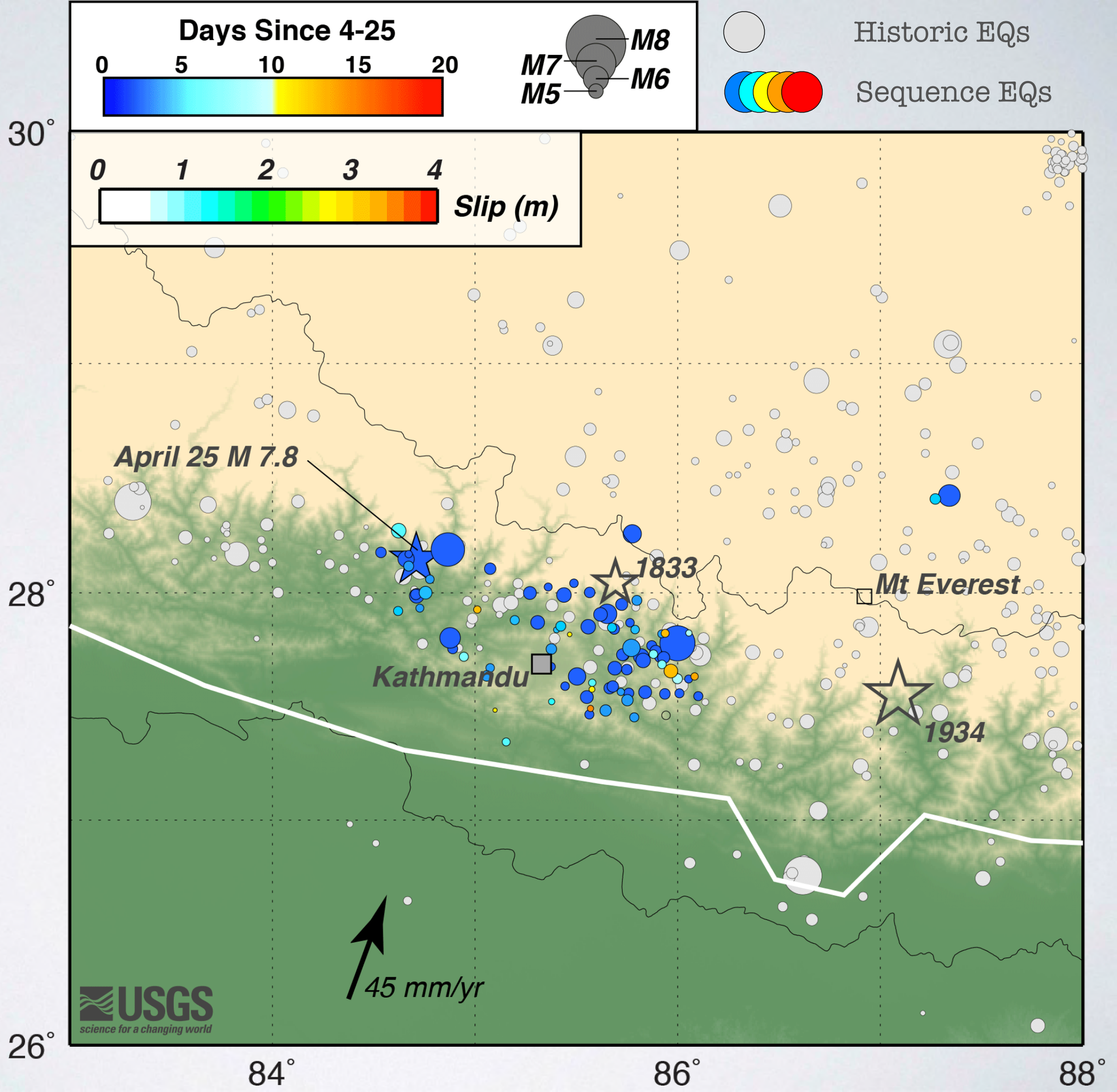




Event pages linked directly from text messages; instant access to all event-based info in new, phone-friendly web format.

Overview

M 7.8 mainshock on 04-25, ~80 km NW of Kathmandu.



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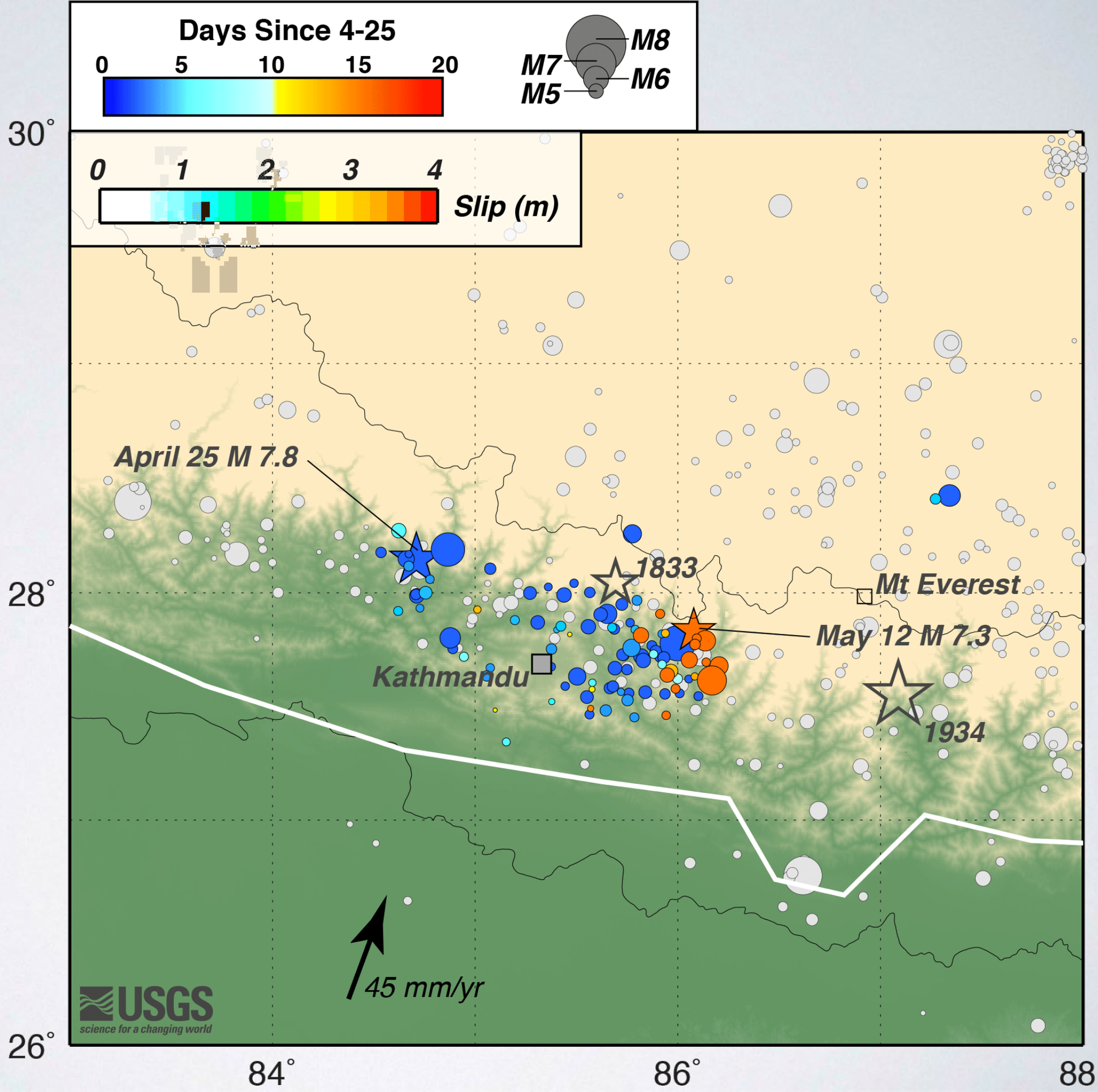
M 7.8 mainshock on 04-25, ~80 km NW of Kathmandu.

~100 subsequent aftershocks, most east of mainshock.

M 7.3 aftershock on 05-12, ~80 km NE of Kathmandu.



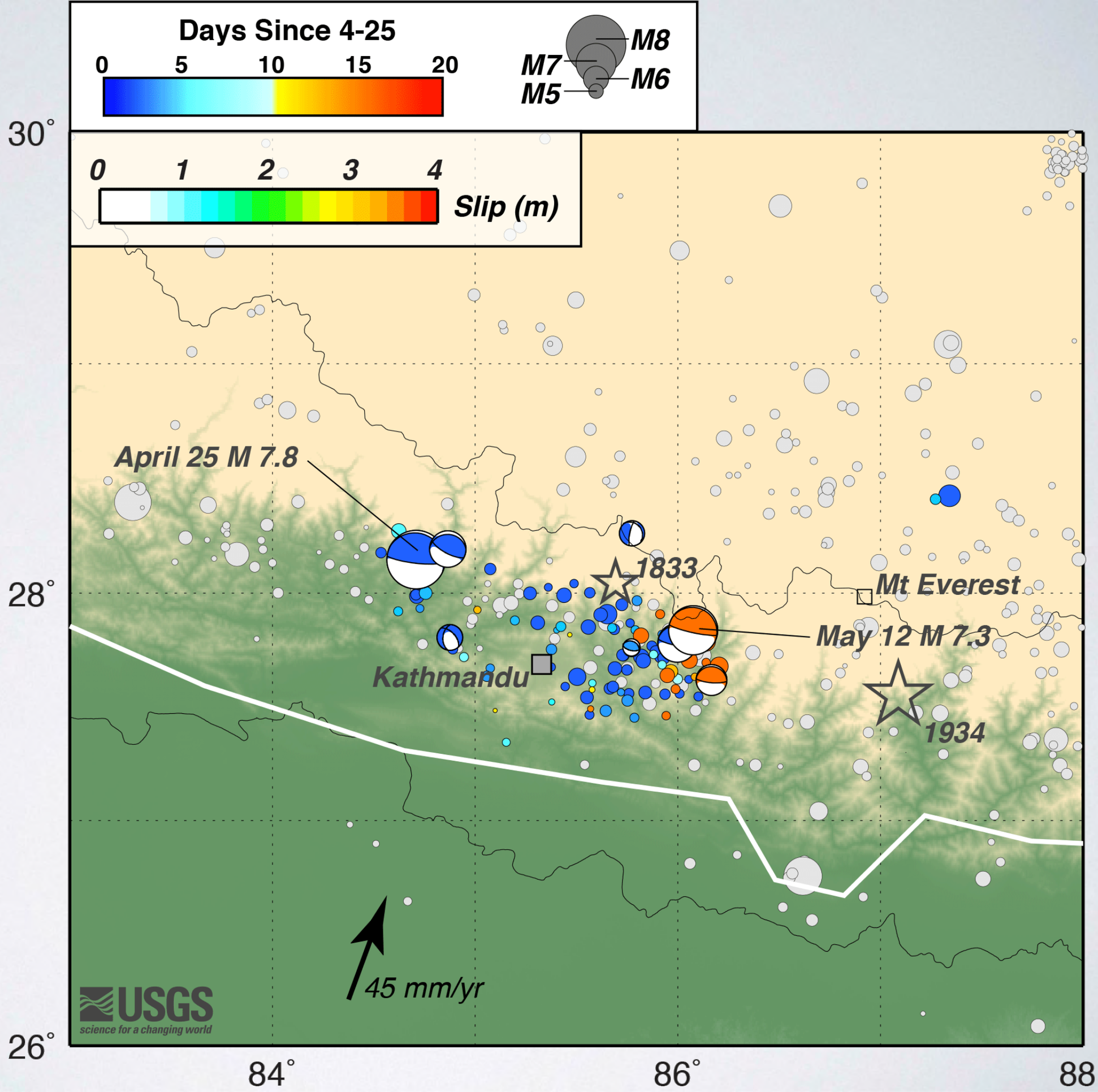
Overview

M 7.8 mainshock on 04-25, ~80 km NW of Kathmandu.

~100 subsequent aftershocks, most east of mainshock.

M 7.3 aftershock on 05-12, ~80 km NE of Kathmandu.

Most EQs shallow angle thrust faulting; likely on decollement of Himalaya Thrust. Some normal fault aftershocks.

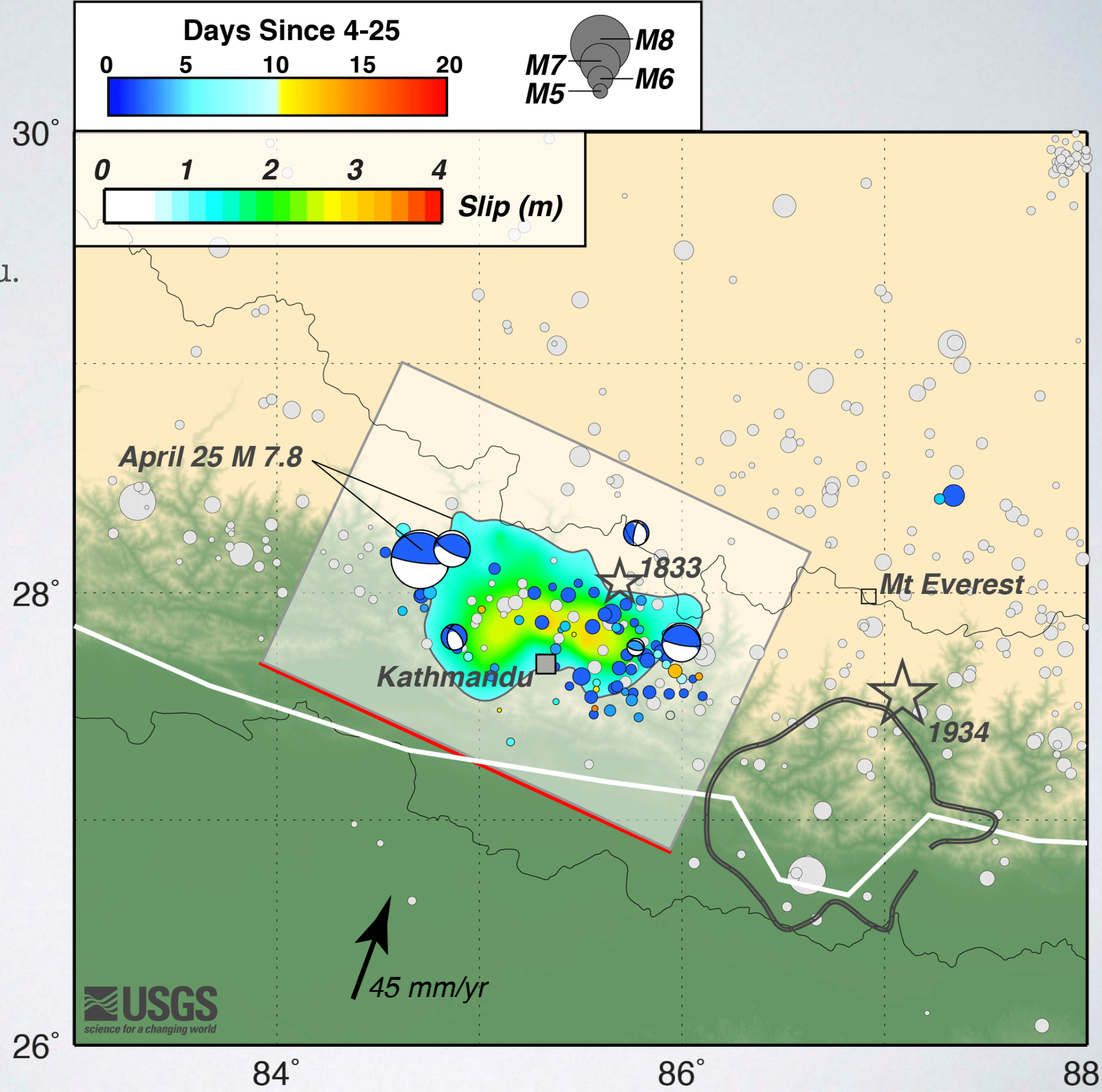


Overview

Mainshock slip directed east from hypocenter, towards Kathmandu.

Peak slip >4m. Dimensions ~120 x 80 km.

Similar location and extent to 1833 M~7.7 EQ. Adjacent to 1934 M 8+ EQ.



Overview

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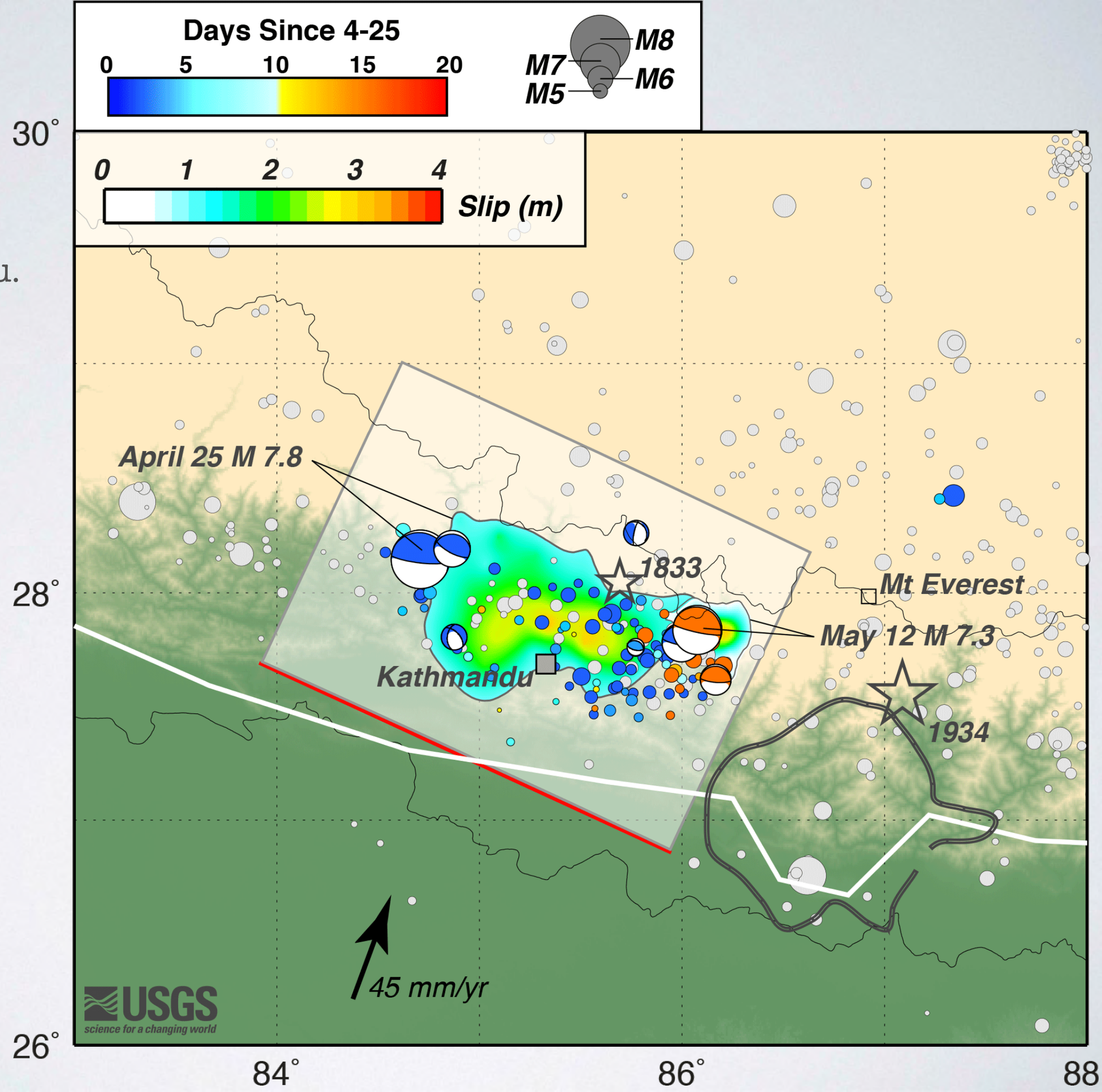
Peak slip >4m. Dimensions ~120 x 80 km.

Similar location and extent to 1833 M~7.7 EQ. Adjacent to 1934 M 8+ EQ.

M7.3 aftershock at NE extent of mainshock; slip close to 4m, dimensions ~40 x 30 km. Resolvable NW rotation wrt 4-25 EQ.



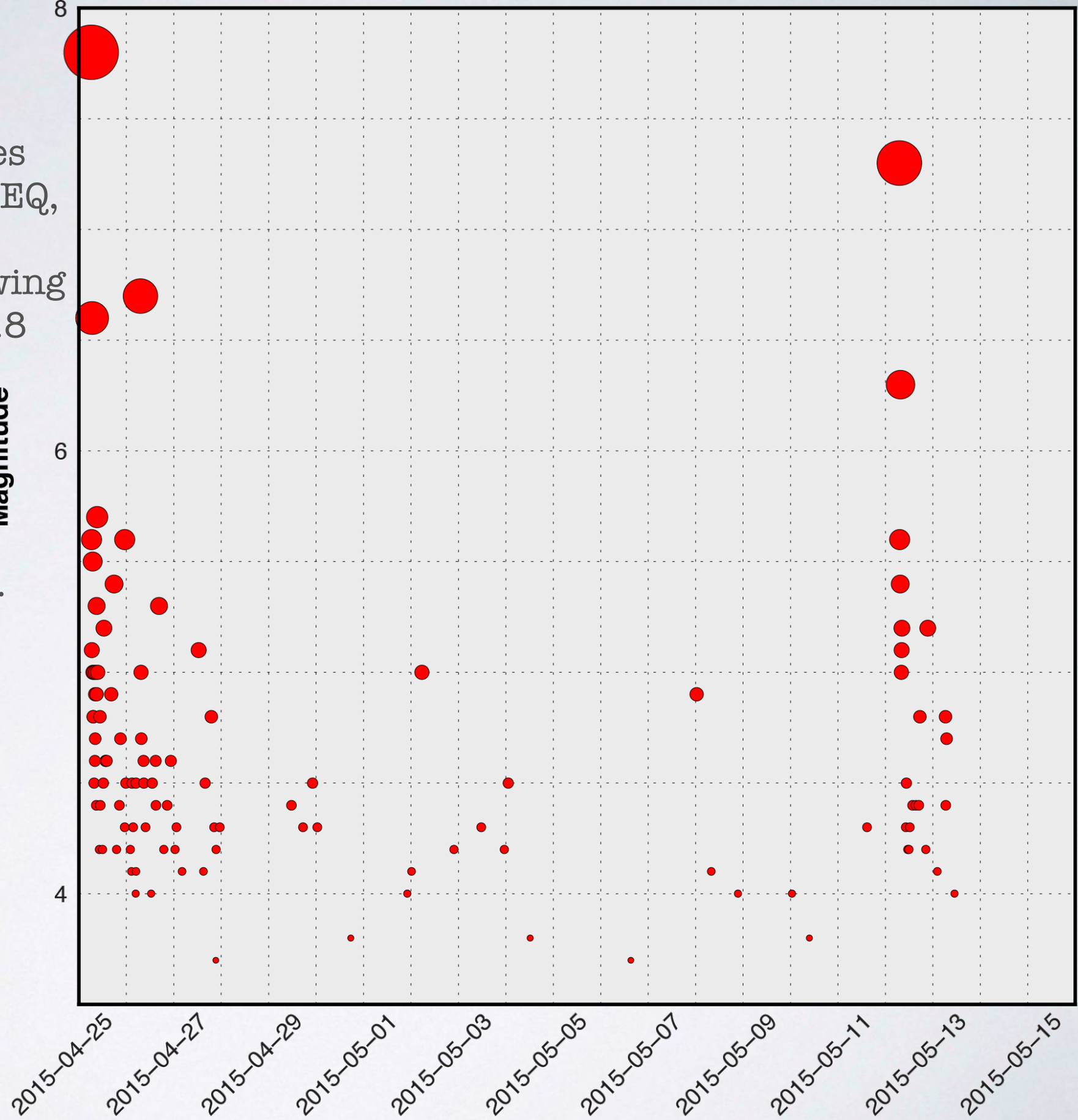
Time History

Aftershocks are earthquakes that occur following a large EQ, in the same general area as that EQ, during the following days-to-years. Both the M 7.8 Gorkha mainshock and the M 7.3 aftershock, have triggered aftershocks.

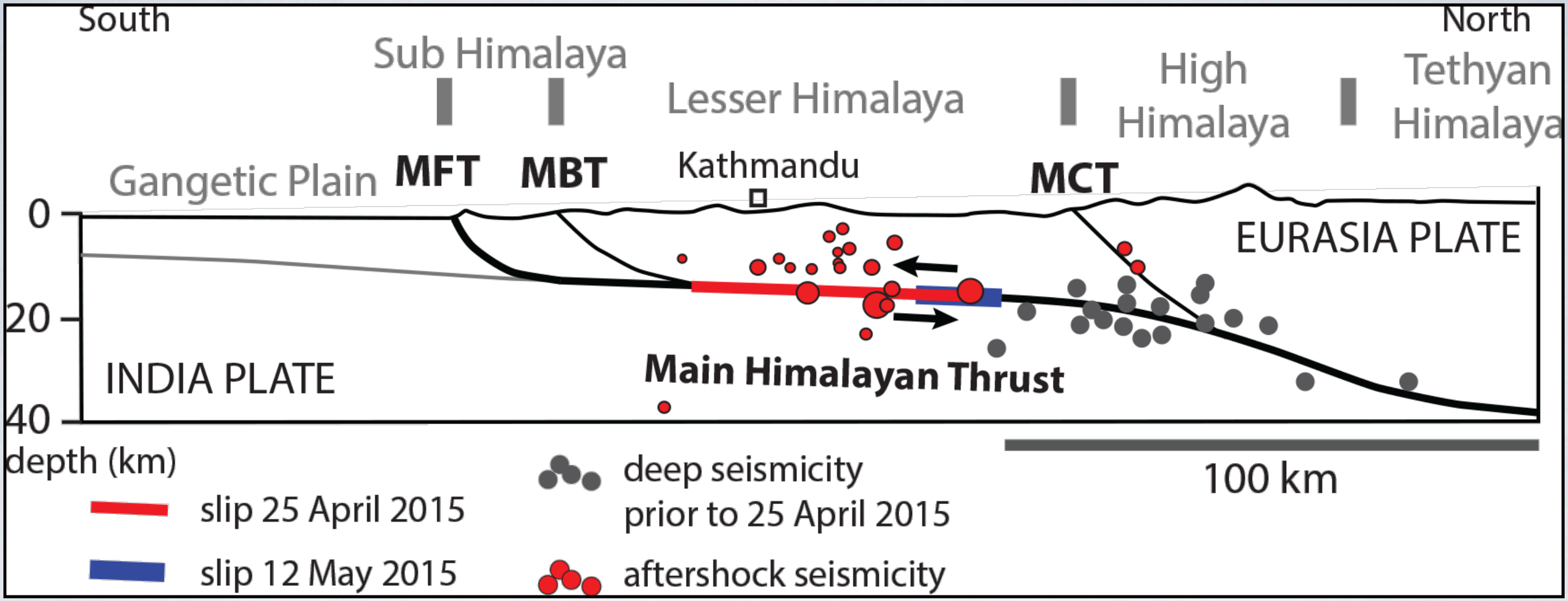
Two M 6.6-6.7 aftershocks within 48 hrs of mainshock.

Subsequent aftershock sequence decayed rapidly, until M7.3 aftershock on 05-12, 17 days after mainshock.

Increase in aftershock activity since M7.3 event, including a M6.3 aftershock soon after that EQ.



Tectonic Context - Cross-Section



Generalized cross section showing the approximate locations of slip during the 25 April and 12 May 2015 ruptures on the Main Himalayan Thrust, and approximate aftershock locations of both events.

MFT = Main Frontal Thrust, MBT = Main Boundary Thrust, MCT = Main Central Thrust.

Cross section generalized after Lave and Avouac, 2001 and Kumar et al., 2006.

Population per ~1km² from LandScan

Scale of Hazard

0	5	50	100	500	1000	5000	10000

The Ganges Delta of northern India has extremely high population density, in an area very close to historic great earthquakes, and/or plate boundary sections with demonstrated high strain accumulation.

Unruptured?

1905 (M~7.9)

1505 (M~8.8)

Delhi

April 25 M 7.8
1833 (M~7.7)

May 12 M 7.3
1934 (M~8.0)

Kathmandu

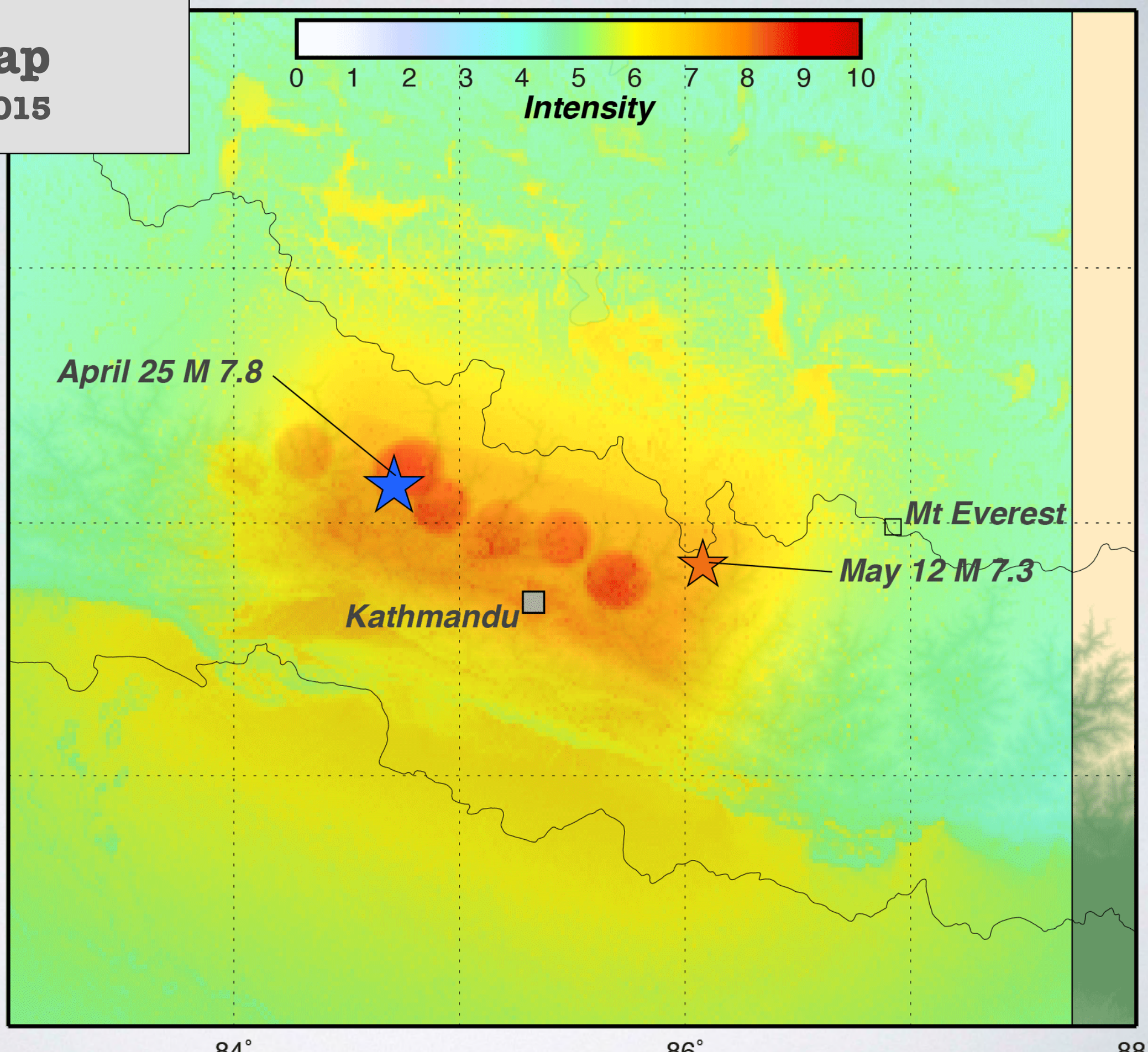
Unruptured?

ShakeMap

April 25th 2015

Broad, very strong-severe shaking, elongated eastward from hypocenter by EQ finiteness.

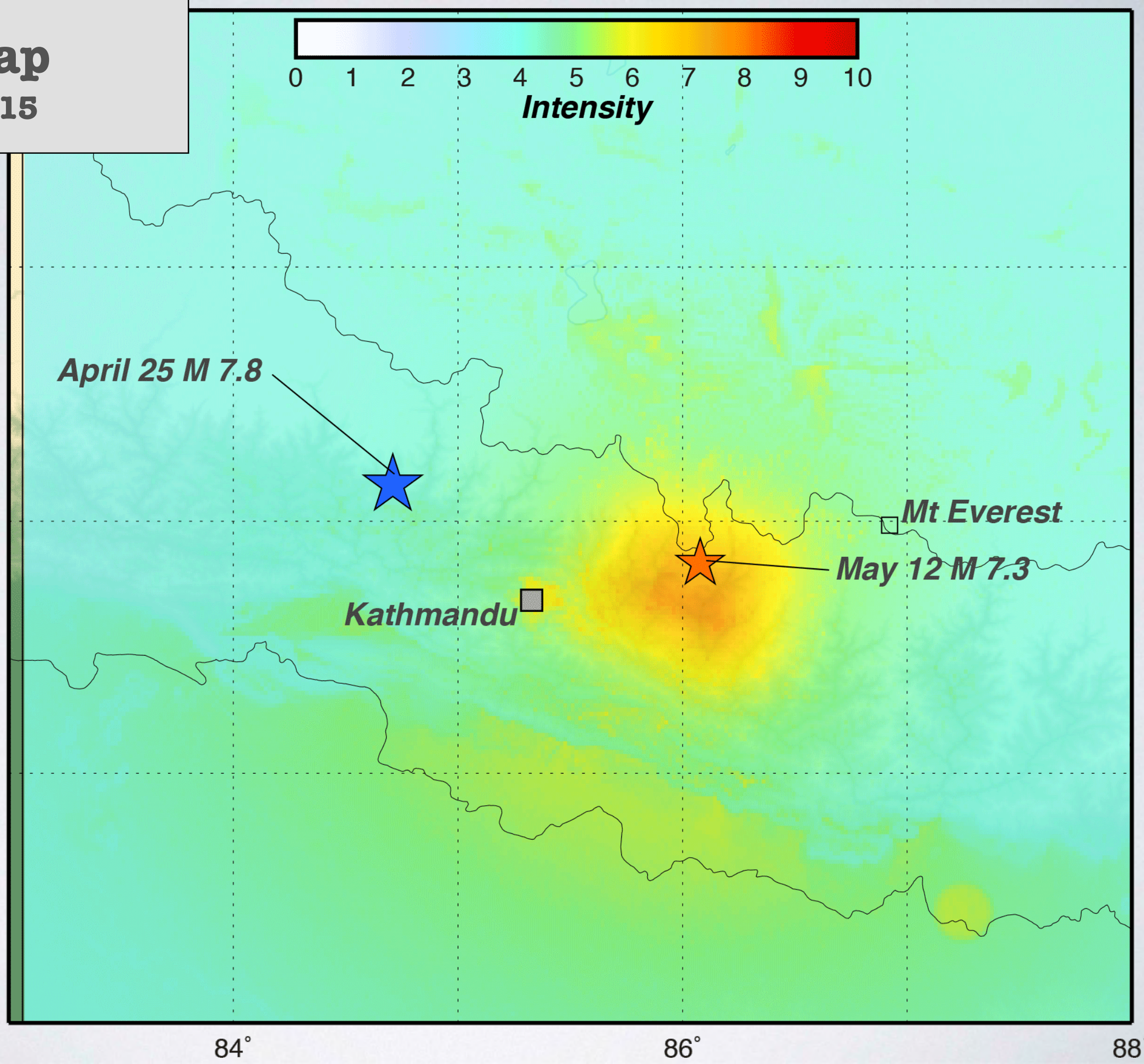
Shaking estimates in epicentral region are poorly constrained due to fewer intensity observations (as well as lack of strong motion data).



ShakeMap

May 12th 2015

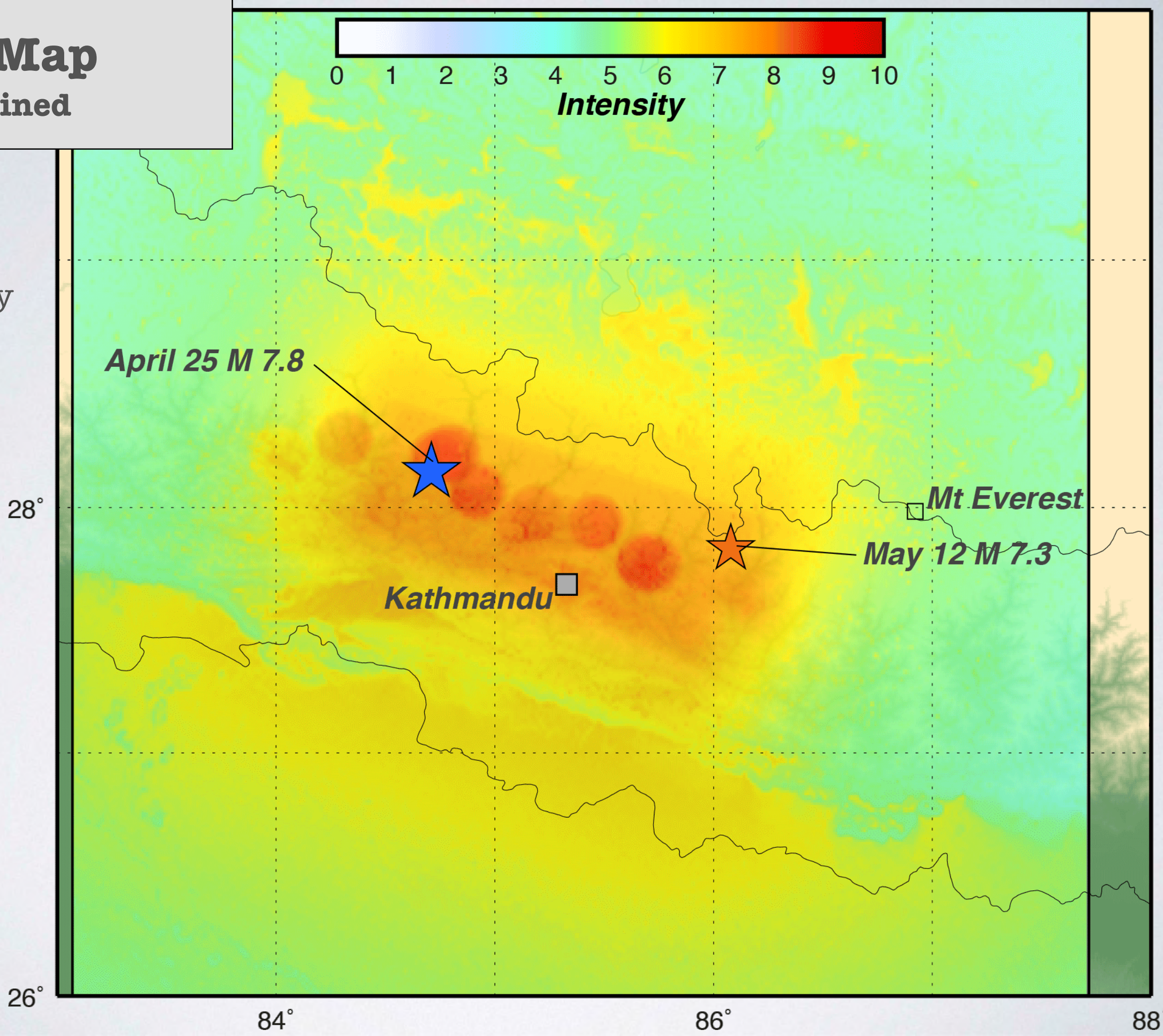
Predominantly strong-very strong shaking, focussed around aftershock hypocenter (smaller source dimensions).



ShakeMap

EQs Combined

Combined shaking intensity dominated by mainshock.

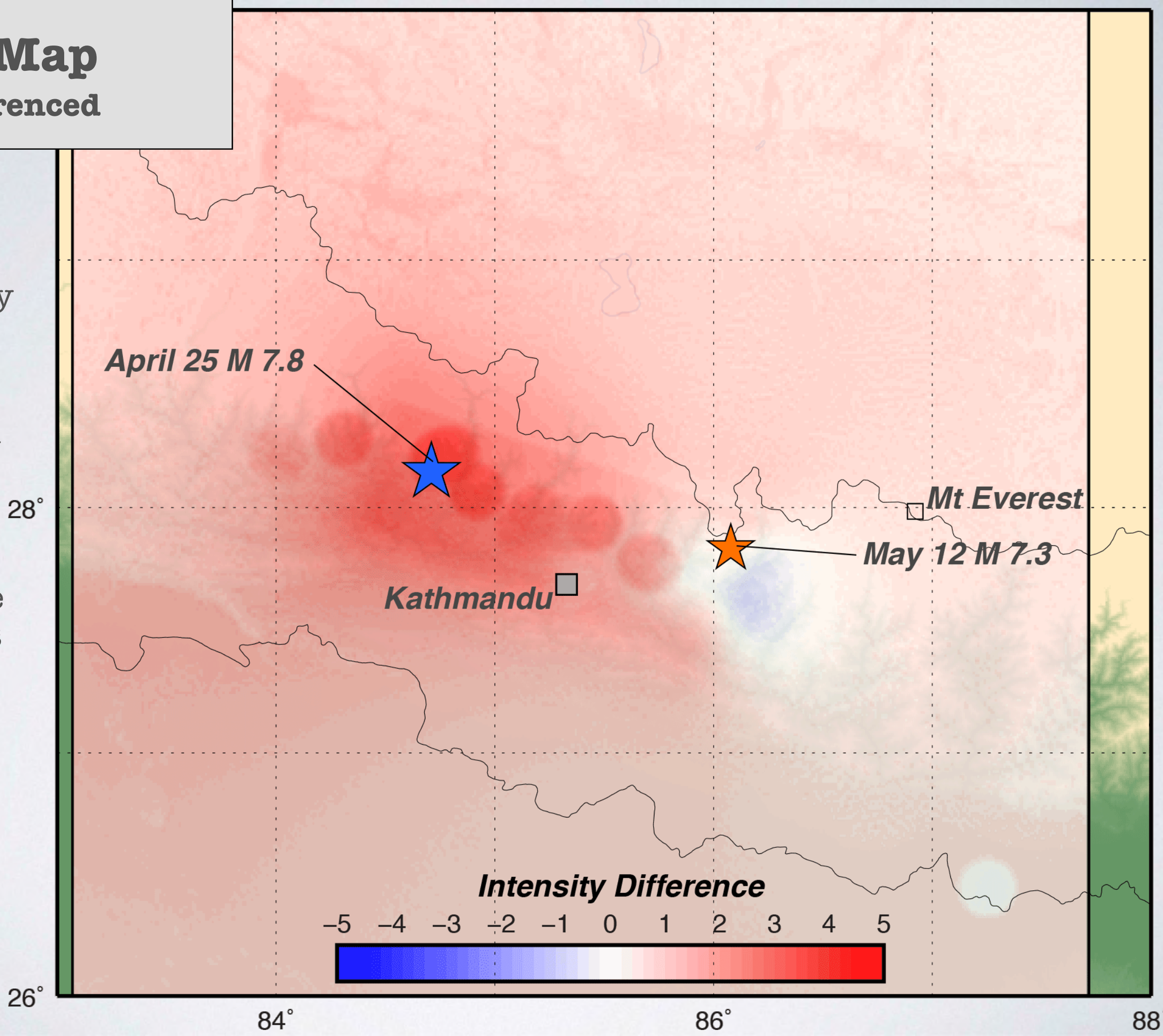


ShakeMap

EQs Differenced

Combined shaking intensity dominated by mainshock.

Aftershock shaking only higher than mainshock in eastern Nepal, where population is lower.



PAGER

April 25th 2015

Combination of broad, very strong-severe shaking leads to high exposure and thus an international-level alert; large numbers of fatalities, and economic losses.

Median loss estimation:
~ 9,000 fatalities
~ $4B direct economic loss

- EQ occurred during work hours (many people were outdoors)

- Housing in rural areas are one-two story construction, with a relatively lighter roof (Tins/GI sheets). High damage rate even at low shaking, but often leads to low fatality rates.

- Majority of newer, multi-story buildings performed reasonably well (sustained damage, but did not collapse).

USGS science for a changing world

Earthquake Shaking — Red Alert

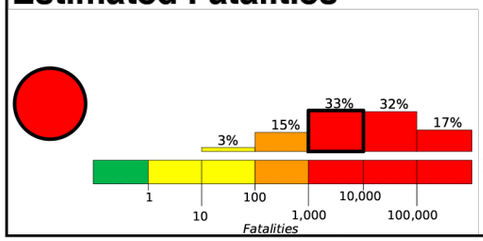
GSN ANSS USAID FROM THE AMERICAN PEOPLE

M 7.8, NEPAL

Origin Time: Sat 2015-04-25 06:11:26 UTC (11:56:26 local)
Location: 28.15°N 84.71°E Depth: 15 km

PAGER Version 7
Created: 1 week, 2 days after earthquake

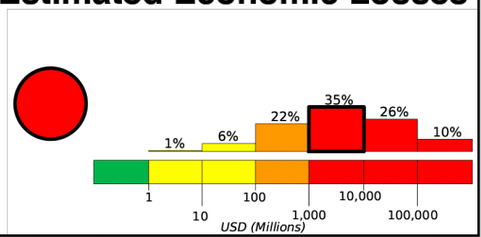
Estimated Fatalities



Red alert for shaking-related fatalities and economic losses. High casualties and extensive damage are probable and the disaster is likely widespread. Past red alerts have required a national or international response.

Estimated economic losses are 10-70% GDP of Nepal.

Estimated Economic Losses



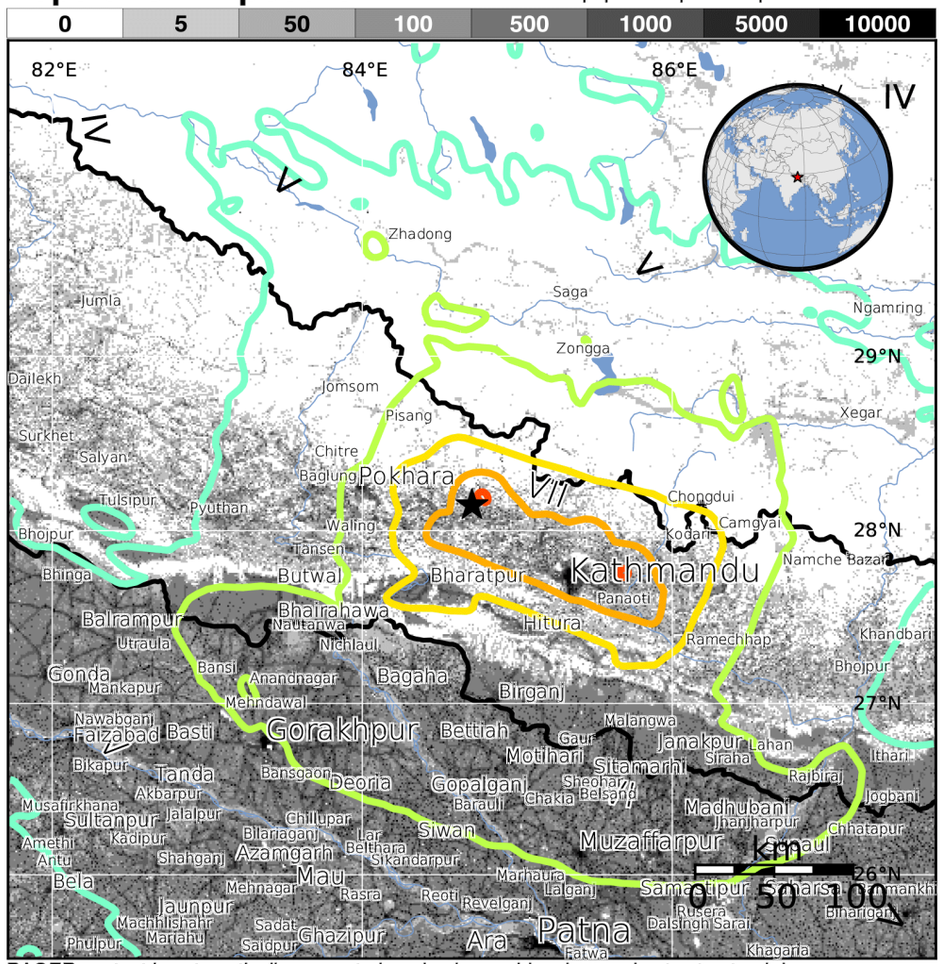
Estimated Population Exposed to Earthquake Shaking

ESTIMATED POPULATION EXPOSURE (k = x1000)		- -*	- -*	7,053k*	82,752k*	55,057k	2,355k	4,483k	86k	0
ESTIMATED MODIFIED MERCALLI INTENSITY		I	II-III	IV	V	VI	VII	VIII	IX	X+
PERCEIVED SHAKING		Not felt	Weak	Light	Moderate	Strong	Very Strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	Resistant Structures	none	none	none	V. Light	Light	Moderate	Moderate/Heavy	Heavy	V. Heavy
	Vulnerable Structures	none	none	none	Light	Moderate	Moderate/Heavy	Heavy	V. Heavy	V. Heavy

*Estimated exposure only includes population within the map area.

Population Exposure

population per ~1 sq. km from Landscan



Structures:
Overall, the population in this region resides in structures that are highly vulnerable to earthquake shaking, though some resistant structures exist. The predominant vulnerable building types are unreinforced brick masonry and rubble/field stone masonry construction.

Historical Earthquakes (with MMI levels):

Date (UTC)	Dist. (km)	Mag.	Max MMI(#)	Shaking Deaths
1980-07-29	364	5.5	VII(18k)	0
1980-07-29	388	6.5	IX(11k)	100
1988-08-20	244	6.8	VIII(12k)	1k

Recent earthquakes in this area have caused secondary hazards such as landslides and liquefaction that might have contributed to losses.

Selected City Exposure

from GeoNames.org

MMI	City	Population
VIII	**Kathmandu**	**1,442k**
VIII	Patan	183k
VIII	Kirtipur	45k
VIII	Bhaktapur	< 1k
VIII	Banepa	17k
VIII	**Panaoti**	**28k**
VI	**Pokhara**	**200k**
VI	**Muzaffarpur**	**333k**
V	**Gorakhpur**	**674k**
V	**Patna**	**1,600k**
V	Dhankuta	22k

bold cities appear on map (k = x1000)

PAGER content is automatically generated, and only considers losses due to structural damage. Limitations of input data, shaking estimates, and loss models may add uncertainty.
http://earthquake.usgs.gov/pager

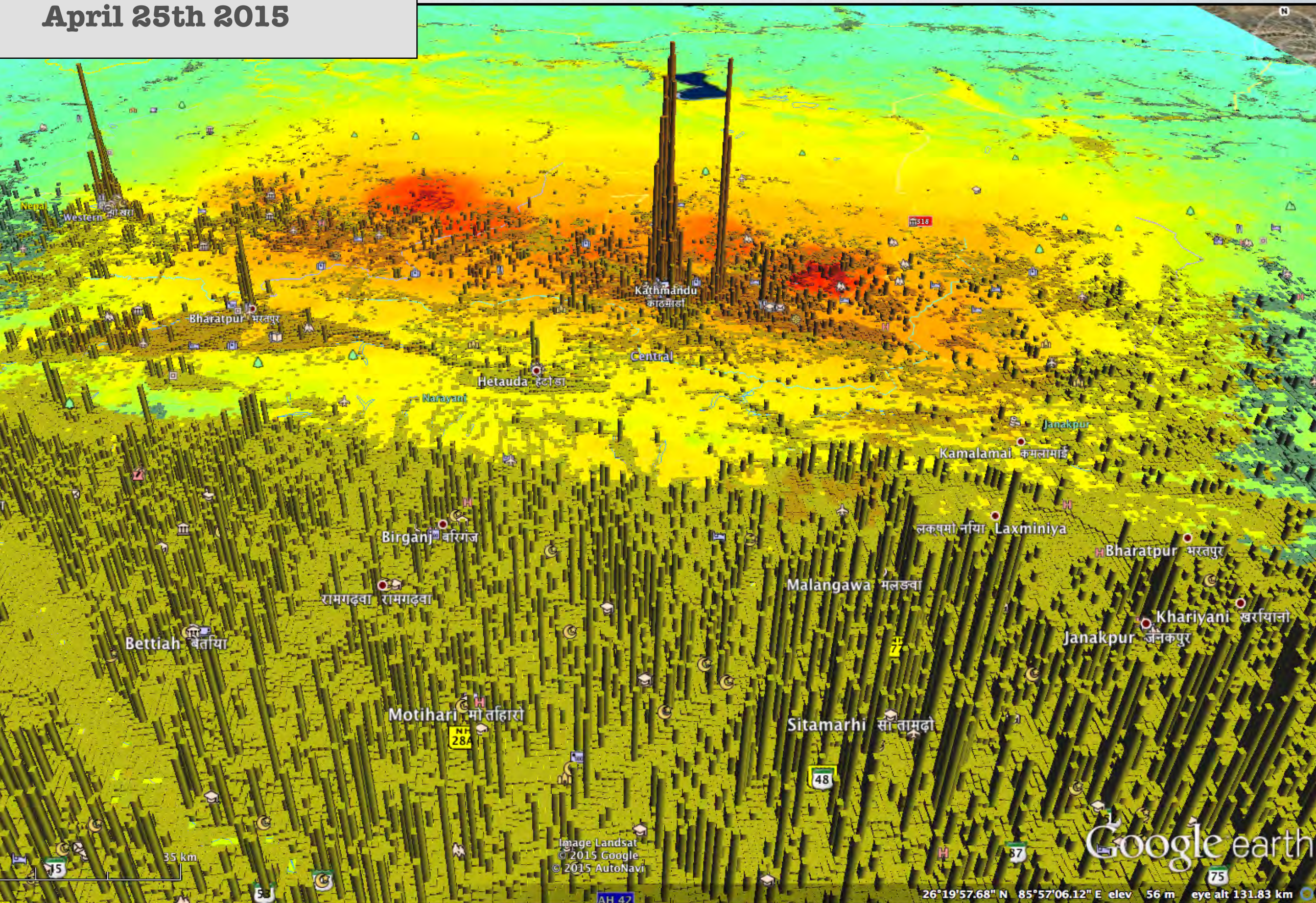
Event ID: us20002926

Exposure

April 25th 2015

bars represent population/km^2; color shaking intensity

by Kishor Jaiswal, USGS GHSC



PAGER

May 12th 2015

Smaller sized EQ, and smaller source dimensions, leads to strong-very strong shaking in a more focussed, lower population area.

Median loss estimation:
~ 160 fatalities
~ $60M direct economic loss

USGS science for a changing world

Earthquake Shaking — Orange Alert

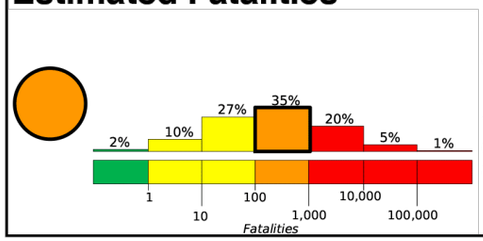
GSN ANSS USAID FROM THE AMERICAN PEOPLE

M 7.3, NEPAL

Origin Time: Tue 2015-05-12 07:05:19 UTC (12:50:19 local)
Location: 27.84°N 86.08°E Depth: 15 km

PAGER Version 3
Created: 2 hours, 5 minutes after earthquake

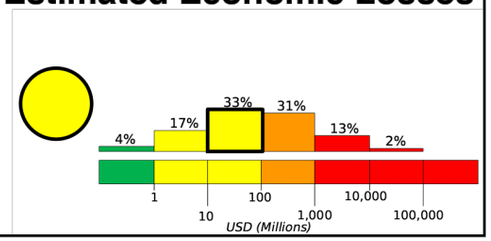
Estimated Fatalities



Orange alert level for shaking-related fatalities. Significant casualties are likely and the disaster is potentially widespread. Past events with this alert level have required a regional or national level response.

Yellow alert level for economic losses. Some damage is possible. Estimated economic losses are 0-1% GDP of Nepal.

Estimated Economic Losses



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ESTIMATED MODIFIED MERCALLI INTENSITY		I	II-III	IV	V	VI	VII	VIII	IX	X+
PERCEIVED SHAKING		Not felt	Weak	Light	Moderate	Strong	Very Strong	Severe	Violent	Extreme
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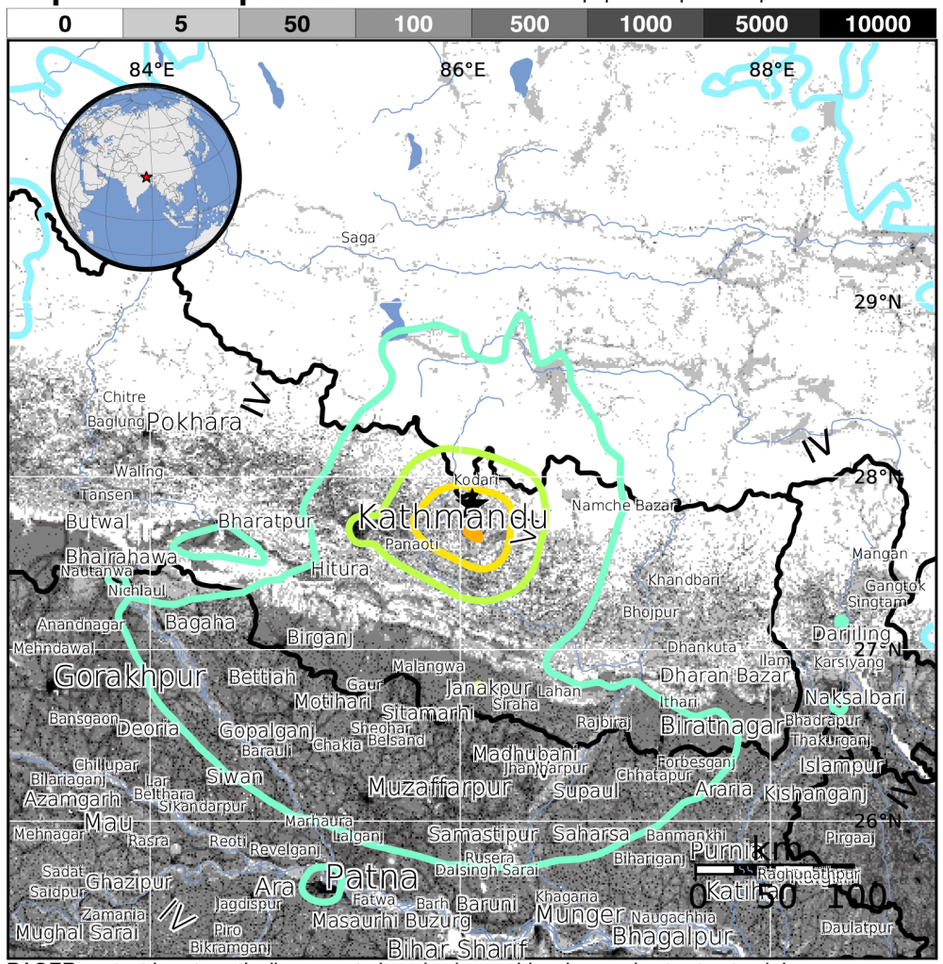
Population Exposure

population per ~1 sq. km from Landscan



Structures:
Overall, the population in this region resides in structures that are highly vulnerable to earthquake shaking, though some resistant structures exist. The predominant vulnerable building types are unreinforced brick with mud and unknown/miscellaneous types construction.

Historical Earthquakes (with MMI levels):

Date (UTC)	Dist. (km)	Mag.	Max MMI(#)	Shaking Deaths
1998-09-03	77	5.6	VII(21)	0
1974-03-24	17	5.7	VIII(598)	0
1988-08-20	131	6.8	VIII(12k)	1k

Recent earthquakes in this area have caused secondary hazards such as landslides and liquefaction that might have contributed to losses.

Selected City Exposure

from GeoNames.org

MMI	City	Population
VI	Zham	< 1k
VI	**Kodari**	**2k**
VI	Bhaktapur	< 1k
VI	**Kathmandu**	**1,442k**
VI	Zuobude	< 1k
VI	Camgyai	< 1k
V	**Patna**	**1,600k**
IV	**Gorakhpur**	**674k**
IV	**Dhankuta**	**22k**
IV	**Pokhara**	**200k**
IV	**Gangtok**	**31k**

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http://earthquake.usgs.gov/pager

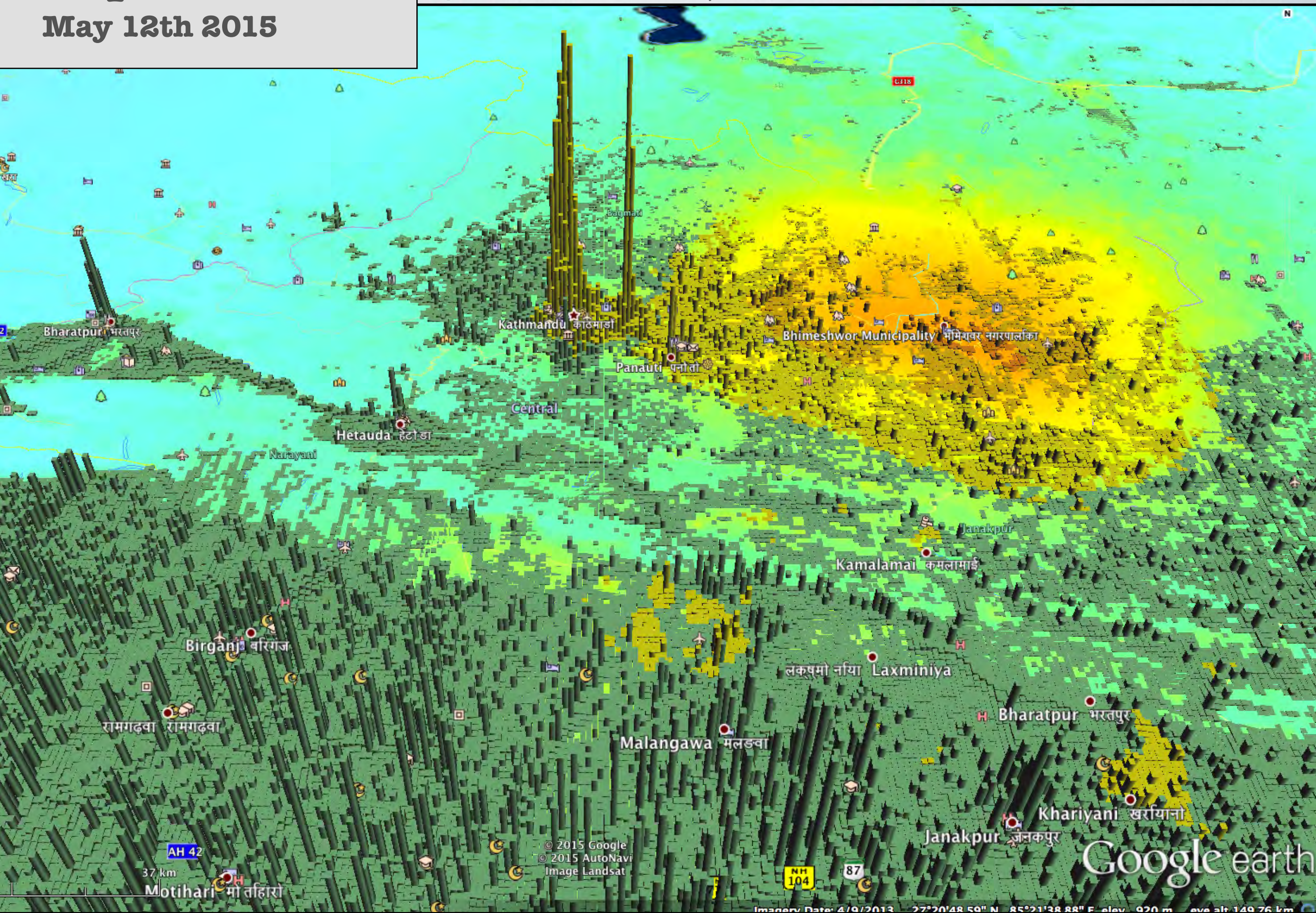
Event ID: us20002ejl

Exposure

May 12th 2015

bars represent population/km^2; color shaking intensity

by Kishor Jaiswal, USGS GHSC



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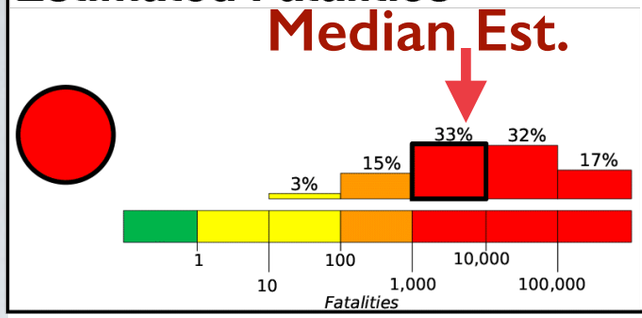
Alert Levels

Estimated Fatalities



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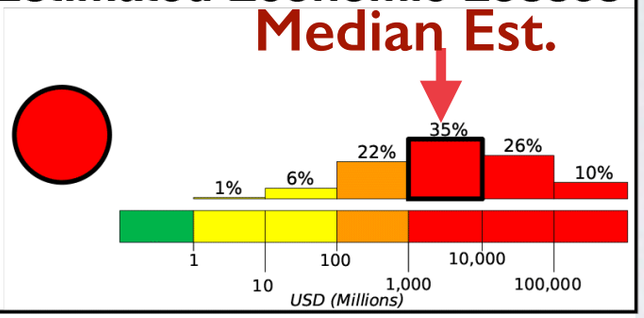

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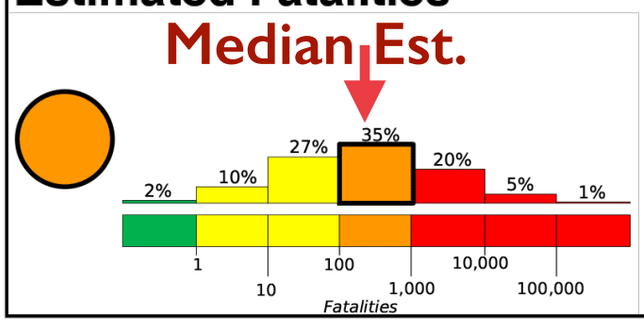

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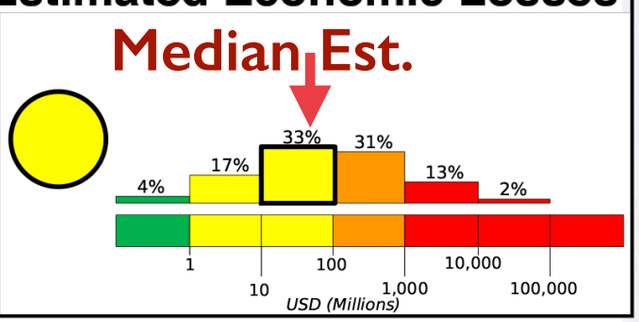

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